



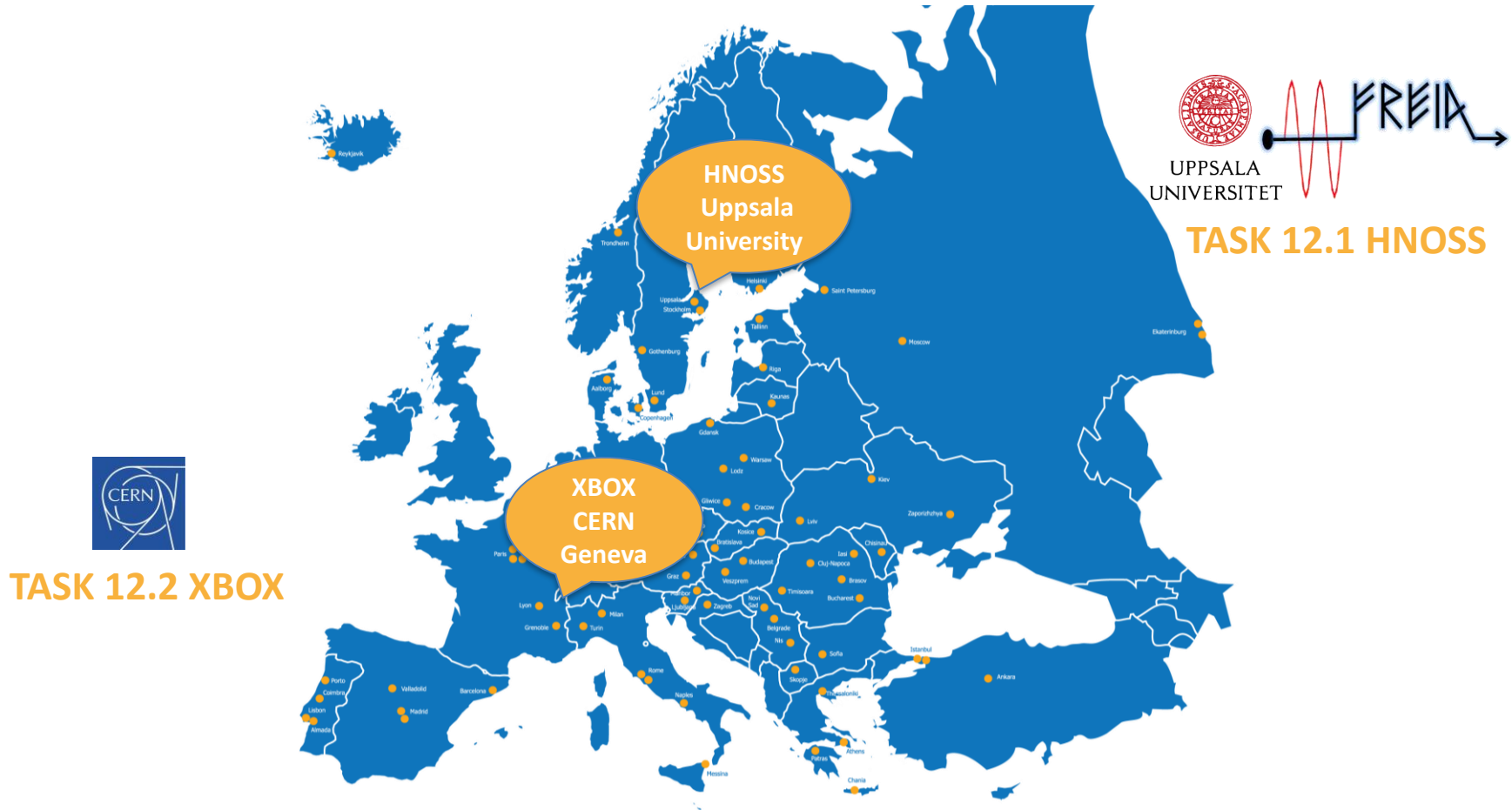
Testing of Advanced RF Structures TNA WP12 RF Test Stands

1st Annual Meeting, Riga, 22-25 May 2018

Roger Ruber (Uppsala University)

Walter Wuensch (CERN)

WP12 RF Testing Facilities



The TNA within WP12 groups **TWO** facilities devoted to testing of superconducting RF cavities and normal conducting RF cavities.

WP12 User Projects

Two user projects received and approved by the USP

- Project 12-01
 - Title: ESS High-beta Elliptical Cavity
 - Duration: 12 months
 - User group leader: Franck Peauger (CEA, France)
 - Facility: UU-FREIA
 - Access: 720 (of 2880) units, 1st (of 4) projects

- Project 12-02
 - Title: Dark and breakdown current studies
 - Duration: 2017-2018
 - User group leader: Marek Jacewcz (UU, Sweden)
 - Facility: CERN-XBOX
 - Access: 1500 (of 6000) units, 1st (of 4) projects

WP12 User Selection Panel (USP)

- Common USP
 - selection based on scientific quality and feasibility,
 - 3 independent experts:
 - Kenneth Österberg (Helsinki Univ., Finland)
 - Jiaru Shi (Tsinghua Univ., China)
 - Slava Yakovlev (Fermilab, US)
 - facility coordinators:
 - Roger Ruber (HNOSS, UU)
 - Walter Wuensch (XBox, CERN)
- User requests
 - contact: e-mail to WP coordinator: ruber@physics.uu.se
- Target is to respond to a request within ~2 months

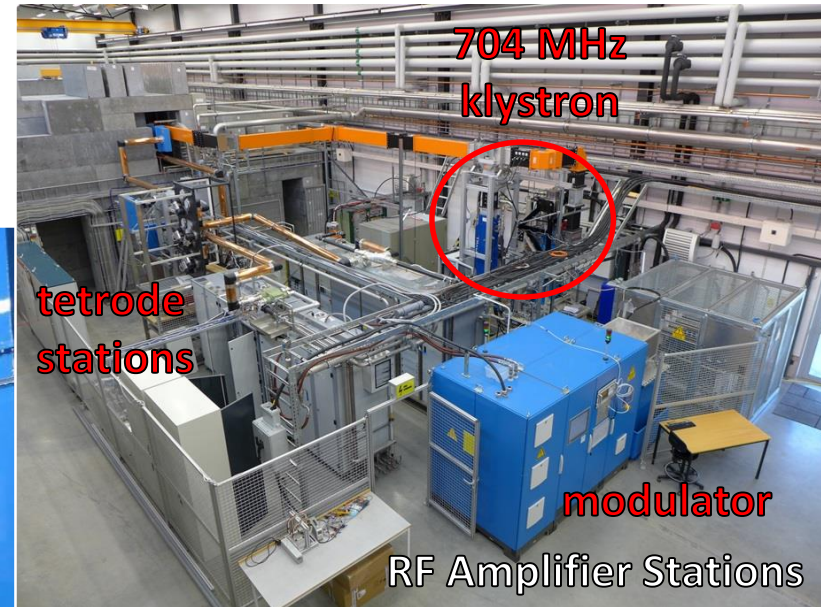
WP12 RF Testing Facilities



The **HNOSS** facility at the FREIA Laboratory, Uppsala University, Sweden, is available for testing of superconducting RF cavities with integrated helium tank.

WP12.1 The Hnoss TNA

- Located at Uppsala University, the HNOSS test stand is used to test and characterize superconducting cavities
- There are 4 RF high power RF sources available, two at 352 MHz at $400 \text{ kW}_{\text{pulsed}}$, one at either 352 or 400 MHz at $50 \text{ kW}_{\text{CW}}$, and one at 704 MHz at $1.5 \text{ MW}_{\text{pulsed}}$, extensive instrumentation and support infrastructure (radiation shielding, SHe & water cooling, vacuum, etc).
- The user community spans
 - High-power proton accelerators
 - High-power electron accelerators

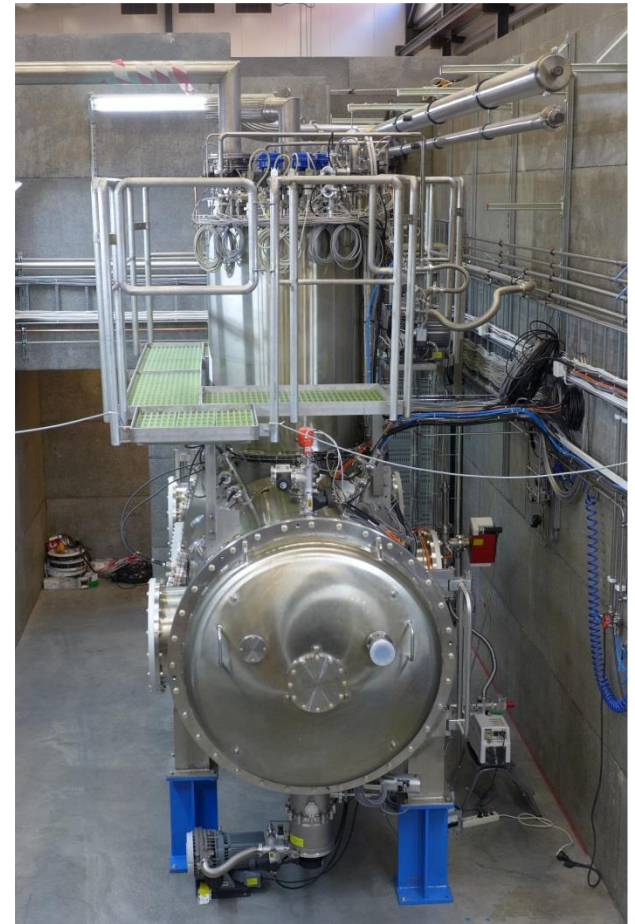


WP12.1 The Hnoss TNA - Facility Overview

HNOSS = Horizontal Nugget for Operation of Superconducting Systems

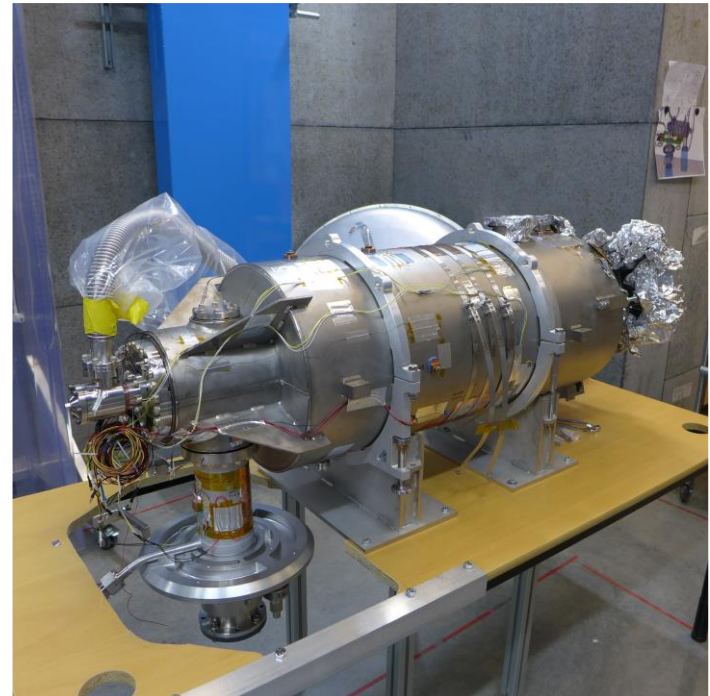
Gersemi & Hnoss are the two daughters of the goddess Freia

- Horizontal cryostat for test and characterization of superconducting cavities:
 - up to two cavities simultaneously,
 - each equipped with helium tank,
 - option: fundamental power coupler and (cold) tuning system
 - supercritical helium and LN2 cooling
- Low or High power RF testing
 - driven by self-excited loop or generator
- Operation in the range 1.8 to 4.5K,
 - sub-atmospheric pumps 90 W at 1.8 K

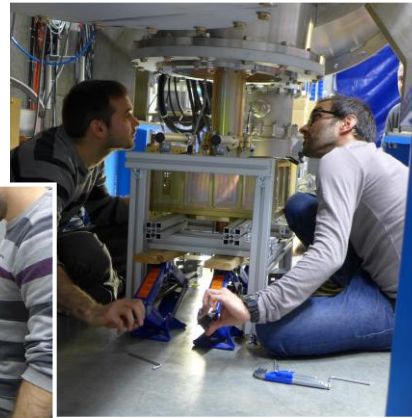
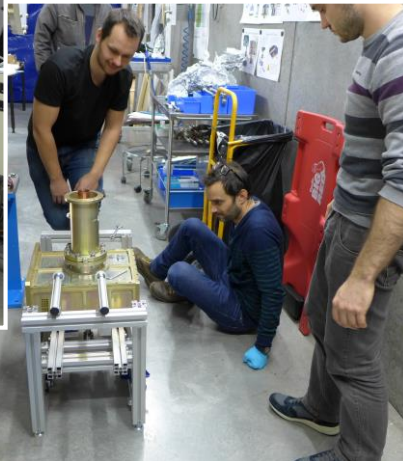


WP12.1 The Hnoss TNA - First TNA

- Test and characterization of a high-beta elliptical cavity with fundamental power coupler and cold tuning system, for CEA Saclay and the ESS,
- Has been installed and commissioning is under way,
 - start-up delayed due to technical issues with the high power klystron and RF-load
- Objective is the validation and characterization of the complete cavity package



WP12.1 The Hnoss TNA - First TNA



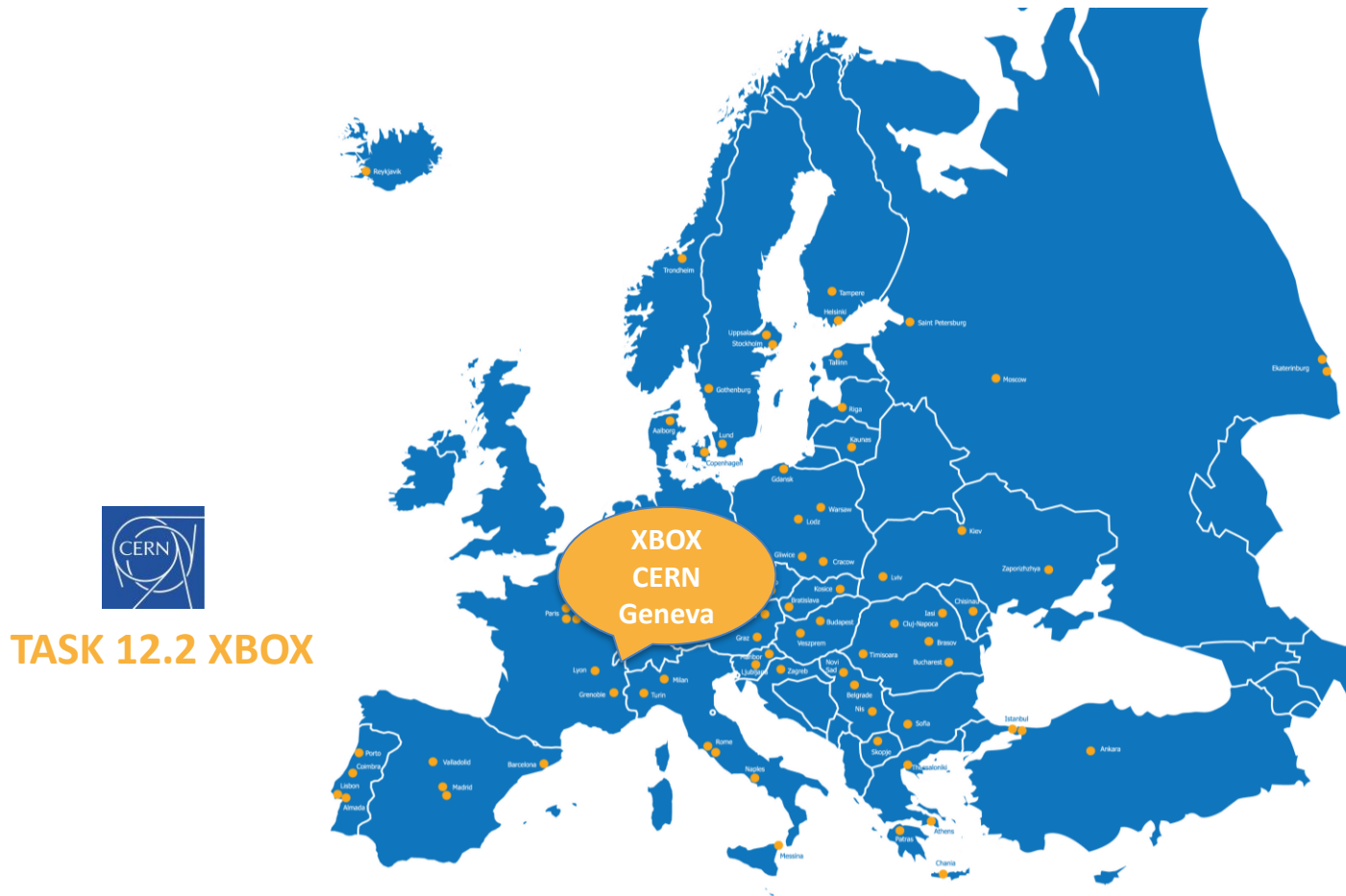
WP12.1 The Hnoss TNA - First TNA



- Preparation of the high power RF source
- on loan from ESS



WP12 RF Testing Facilities



The **XBox** facility at CERN, Switzerland, is available for testing of normal conducting RF cavities/structures at X-band frequency.

WP12.2 The Xbox TNA

- Located at CERN, and built up by the CLIC collaboration, the Xbox test stands are used to carry out high-gradient accelerator technology development and research into the multiple process which occur at high surface fields.
- There are four independent klystron-based test stands with peak powers in the range of 50-150 MW, extensive instrumentation and support infrastructure (radiation shielding, water cooling, vacuum, etc).
- The user community spans:
 - High-performance normal-conducting electron linacs
 - High-gradient proton linac applications such as medical
 - High-power device users such as satellite communication
 - Material science and plasma physics groups who study high-field dynamics

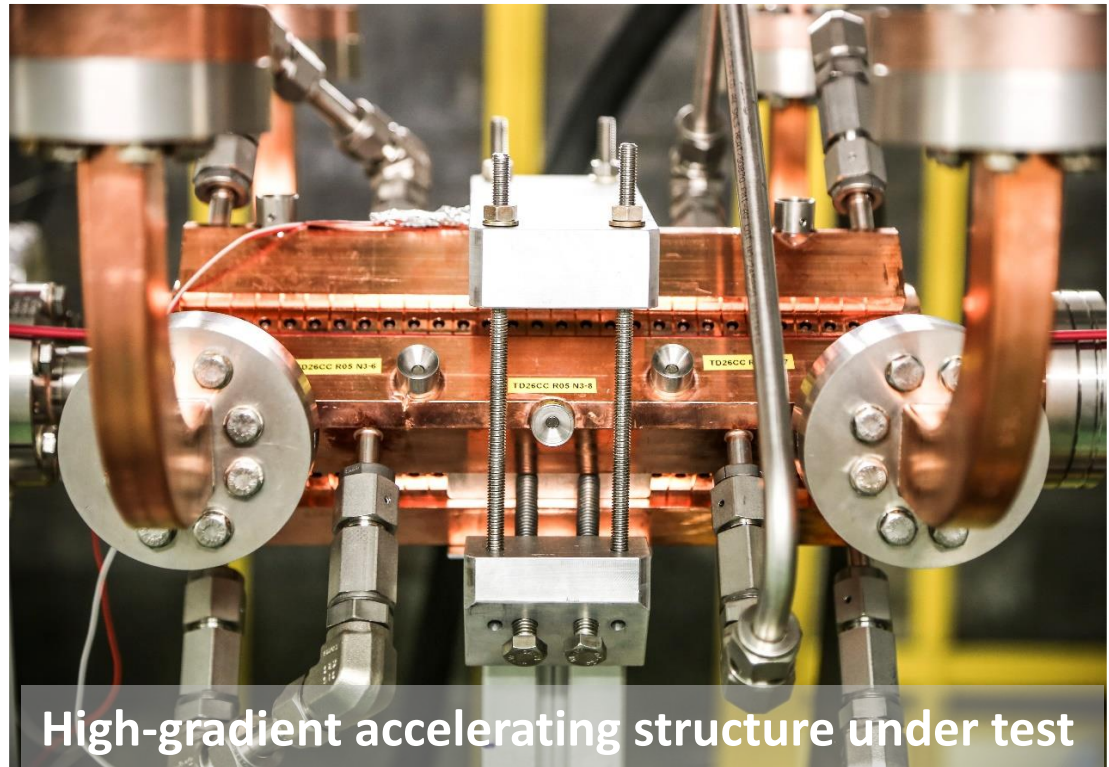


Xbox-3 klystron-modulator rf power unit

WP12.2 The Xbox TNA

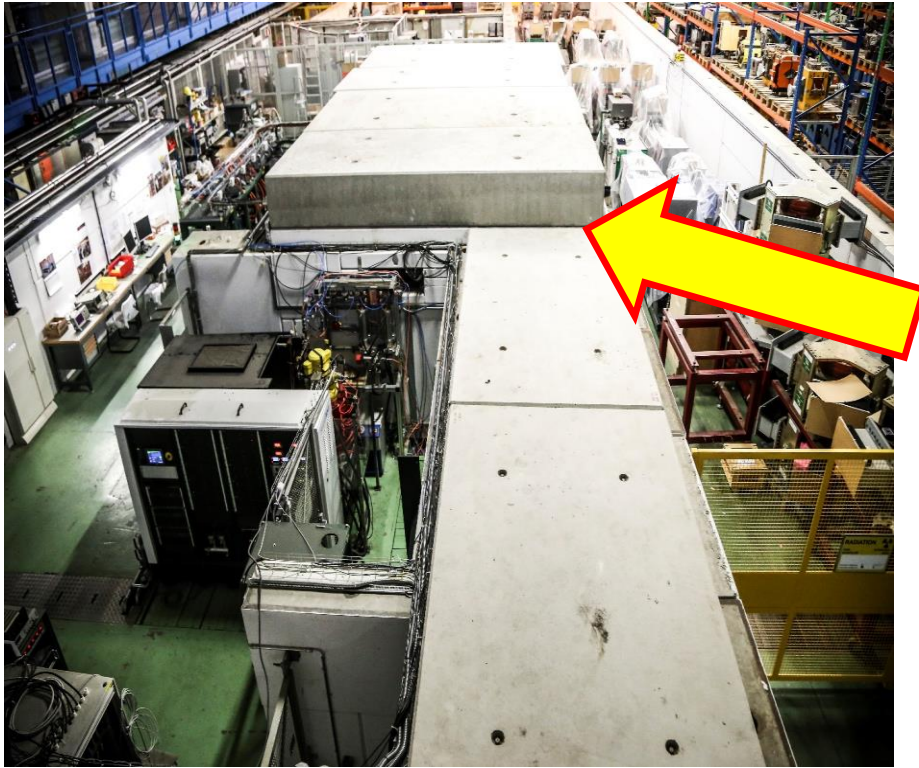
Typical experiments include:

- High-gradient test accelerating structures for ultimate performance, rf design, conditioning, effect of fabrication and preparation, operational control, long-term operation
- High-power test waveguide components including pulse compressors, windows, combiners, mode converters
- High-field studies including breakdown limits and dynamics, field emission, dark current capture, radiation, dynamic vacuum



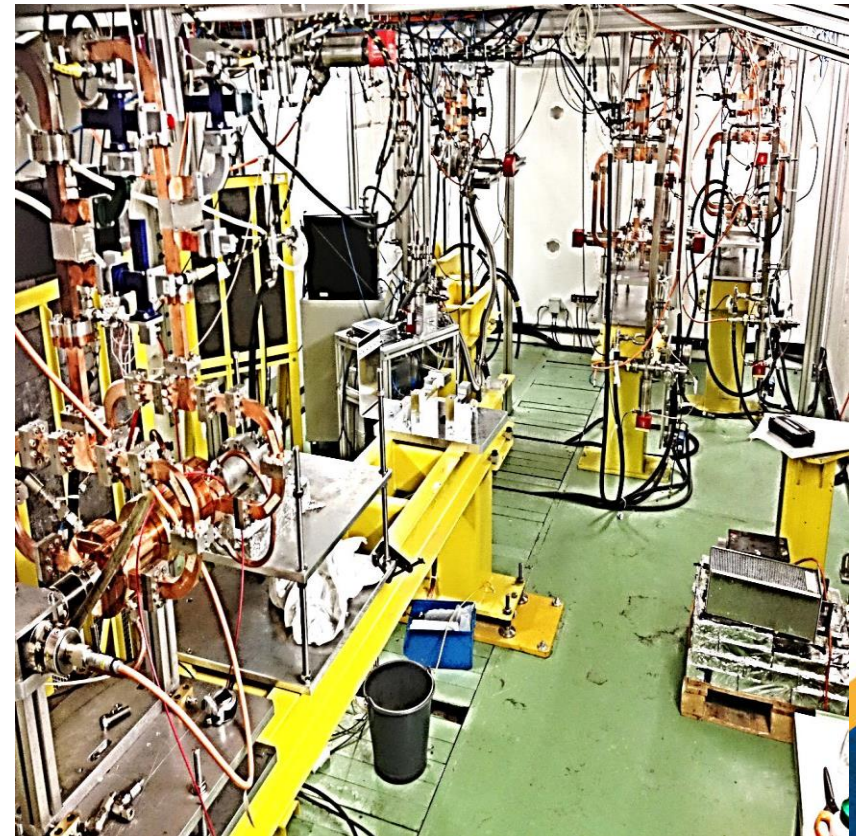
High-gradient accelerating structure under test

WP12.2 The Xbox TNA - Facility Overview



XBox2 power unit outside of experimental bunker

Inside experimental bunker



WP12.2 The Xbox TNA - Facility Overview

Characteristics:

- 50-150 MW peak power from modulator-klystron-pulse compressor units
- All sub-systems: vacuum, water cooling, e
- Extensive instrumentation
- Full computer control
- 24/7 operation, typical experiments take from days to months.
- We have relatively many access units per user project.
- A generic user project consists of on-site installation, commissioning and initial data taking followed by remote access during extended running

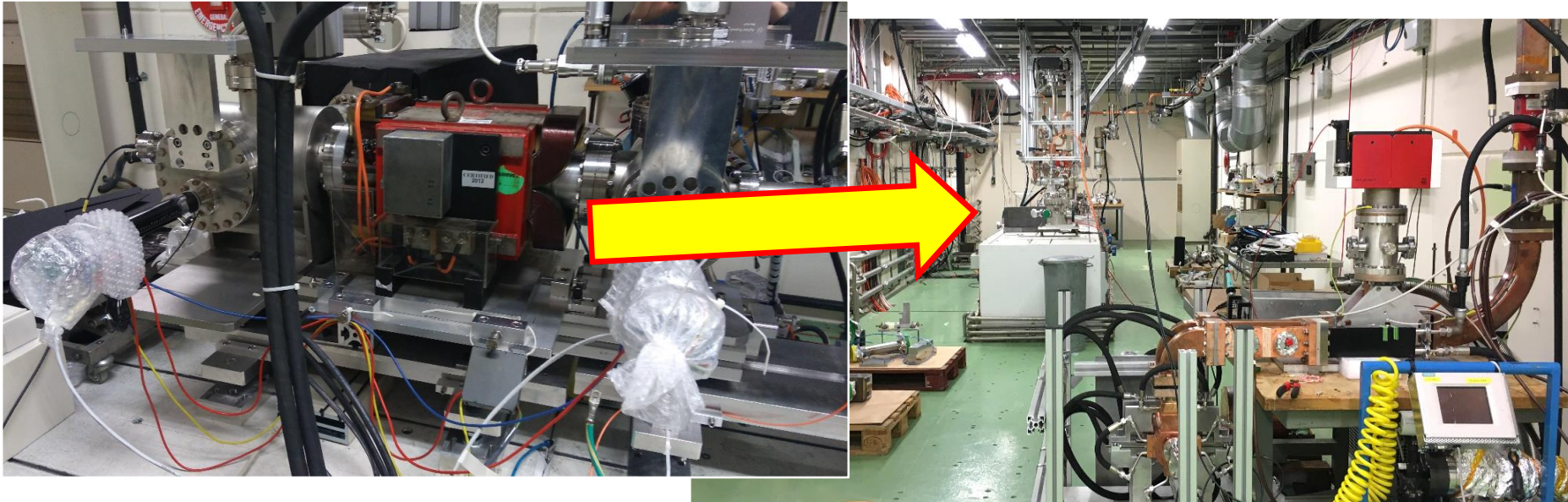


Xbox-1 rf power source



Xbox-1 experimental bunker

WP12.2 The Xbox TNA - First TNA

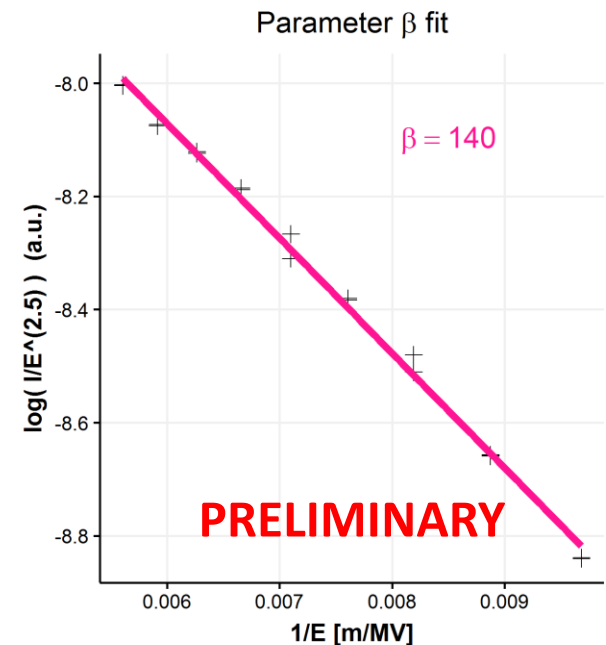
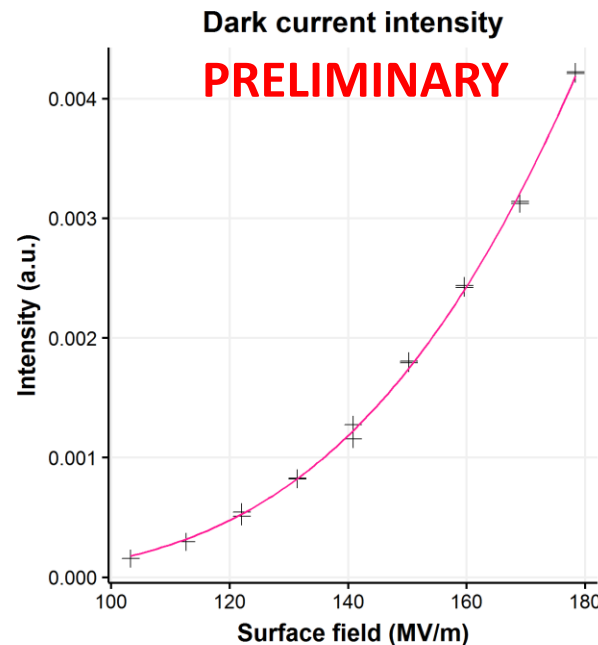


- The first TNA “Dark and breakdown currents studies with the Uppsala X-band Spectrometer” has been installed, commissioned and remote data taking is underway.
- Objective is to study high-field effects using a spectrometer magnet, collimator, screens and fast cameras.

WP12.2 The Xbox TNA - First TNA

- Dark current can give information about changes inside the structure during conditioning:
 - use the spectrometer to look at the changes, both spatially on the screen and by measuring the energy spectrum
- Enhancement factor β accounts for the increase in a local (microscopic) field value E_{local} from the ideal surface field E
 - $E_{\text{local}} = \beta * E$

- **Good agreement with underlying theory of field emission**



WP12.2 The Xbox TNA - Outlook

- The first TNA User Project is underway, will continue during the coming months
- Discussions are underway with various groups for future User Projects. We hope to see the next proposal in the coming months.
- Four user Projects are promised in the proposal. A typical User Project is quite complex, often requires some form of approval at the level of the proposing institutes, so lead times are long. But we should be OK.
- Next advertising pushes will be dedicated posters at two international workshops:

7TH INTERNATIONAL WORKSHOP ON MECHANISMS OF VACUUM ARCS (MeVArc)



**SAN JUAN, PUERTO RICO
MAY 21-24, 2018**

Vacuum arcs are a concern in essentially every vacuum electronic device. Sometimes they form the basis for device operation, but all too often they are the primary failure mode. They are often described as high voltage breakdown (HVB) and electrostatic discharge (ESD) as well. The purpose of this workshop is to bring together scientists and engineers to discuss the latest improvements in our understanding of vacuum arcs, including their initiation and evolution

EXPERIMENTS

Vacuum Arcs
DC Spark Systems
Materials
Diagnostics
Technologies for High Gradients
Arcing in Fusion Devices

THEORY AND SIMULATIONS

Arc Initiation and Evolution
Simulations (PIC-DSMC, MD, KMC, etc.)
Plasma-Wall Interactions
Surface Damage and Evolution
Surface Modification from E and B Fields
Dislocation Activity
Cavity Condition and Evolution

APPLICATIONS

Discharge-Based Devices
Particle Accelerators
Electrostatic Failure Mitigation
Fusion Devices
Satellites
Other Industrial Interests

ORGANIZERS

Matt Hopkins (mmhopki@sandia.gov), Sandia National Laboratories, USA

Chris Moore (chmoore@sandia.gov), Sandia National Laboratories, USA

Yinon Ashkenazy (yinion.ash@mail.huji.ac.il), Sandia National Laboratories, USA

Sergio Calatroni (sergio.calatroni@cern.ch), CERN, Switzerland

Ryura Dzurabekova (Ryura.dzurabekova@helsinki.fi), University of Helsinki, Finland

Walter Wuensch (walter.wuensch@cern.ch), CERN, Switzerland

For More information, please contact:

Technical POCs

Matt Hopkins – mmhopki@sandia.gov or Chris Moore – chmoore@sandia.gov

Administrative POC

Idabelle Courtney – icourtn@sandia.gov

<https://indico.cern.ch/event/680402/>

SINAP

June 4-8, 2018
Shanghai Institute of Applied Physics,
Chinese Academy of Sciences
SINAP, Shanghai, China

**International Workshop on
Breakdown Science and
High Gradient Technology
HG2018**

<https://indico.cern.ch/event/675785/>

Meeting Chair
Zhaotang Zhao

International Organizing Committee
Yakob Wuensch (CERN)
Toshiyuki Inago (KNSC)
Gennadiy D'Almeida (E3Bn)
Yinon Ash (HUJI)
Jian Guo (Shanghai University)
Vikary Dolgashin (SLAC)
Angela Fiaschi-Cotta (LAL)
Wenrong Fang (SINAP)

Local Organizing Committee
Wenrong Fang
Gang Gu
Zhengxi Hou
Wenping Gu
Jianhua Tan
Xiaocun Huang

<https://indico.cern.ch/event/675785/>

